SCHOOL OF AVIATION MEDICINE
U.S. NAVAL AIR STATION
PENSACOLA FLORIDA

A COMPARISON OF THE RELIABILITY AND VALIDITY OF VISUAL ACUITY TEST TARGETS

Research Project X-676 (Av-357-p) Report No. 1

3 April 1946

NAVAL SCHOOL OF AVIATION MEDICINE
U. S. NAVAL AIR TRAINING BASES
PENSACOLA, FLORIDA

RESEARCH REPORT

SUBMITTED - 3 APRIL 1946

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TITLE: A COMPARISON OF THE RELIABILITY AND VALIDITY OF VISUAL ACUITY TEST TARGETS.

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SUMMARY

The validity of five targets for testing visual acuity was determined through the correlation of test results of each target with the Grow chart scores. In addition, the test-retest reliability of all six tests was studied. The targets under consideration were: The Sight Screener, a New London letter target, two Randolph Field letter targets, and an adaptation of the Ortho-Rater checkerboard type target. One hundred subjects were employed. Acuity scores, obtained in Snellen equivalents, were translated into log-units to facilitate statistical analysis. Additional systems were essayed for scoring each of the Randolph Field tests. Statistical analyses consisted in (1) deriving test-retest reliability coefficients and coefficients of intercorrelation among the test scores by means of product-moment correlation, (2) determining the significance of the differences between test and retest mean scores, (3) determining the significance of the differences between mean scores on the various tests by the *t* tests, and (4) obtaining the conventional measures of dispersion and statistical reliability. Results of the statistical analyses and clinical observations of the examiners relating to each test are presented.

CONCLUSIONS

1. With the exception of the Ortho-Rater type target and the Sight Screener, which have somewhat lower overall reliabilities, there is little practical difference in overall test-retest reliabilities among the various targets.

2. There is no important difference among the targets in correlation with the Grow chart except for the Ortho-Rater and Sight Screener

targets, whose correlations with the Grow chart are consistently lower.

3. Subjects show slight but statistically reliable gain on retest with all targets.

4. Some targets, the Randolph Field 1-unit in particular, consistently tend to give higher mean scores than others.

5. Results shown by the Randolph Field 1-unit decrement target indicate that finer quantitative testing of visual acuity is possible where job analysis requires it. This target also has an advantage in terms of ease and speed of administration.

INTRODUCTION

This project was established to study the reliability and validity of five targets for testing visual acuity. Reliability was determined by a test-retest comparison while validity was determined using the Grow chart as the criterion. Of the five targets, four were mounted upon glass panels for presentation in a cabinet* developed for trans-illumination of test targets. These targets include three of the letter type, a target developed and validated at the New London submarine base and two targets developed and validated at Randolph Field by the AAF. The fourth target was an adaptation of the Ortho-Rater type test target, employing checkerboard pattern discrimination as a measure of acuity. The remaining target, presented in the Sight Screener,** was the "distance acuity" portion of the slide supplied with that instrument. With the exception of the latter the targets were developed for use from a 20' distance and adapted to "walk-up" procedure similar to that employed by the Navy with the Grow chart. Every effort was made further to equate these targets with the Grow in terms of illumination, procedure, et cetera.

PROCEDURE

Experimental Design:

In order to eliminate any undue influence of one test upon another developing from its place within the series, as well as differential effects of fatigue, the tests were presented in rotation. Considering the three trans-illuminated letter targets as one type essentially different from the Grow Chart, Sight Screener, and the Ortho-Rater checkerboard targets, it was possible to design a rotation of presentation with four

* A product of the Bausch & Lomb Optical Company
** A product of the American Optical Company

units. The four units resulted in 24 orders of presentation, with each unit appearing in each serial position with equal frequency. In addition the order of presentation within the trans-illuminated letter group also was rotated. The order of presentation was the same for any one subject on both test and retest. Retests were scheduled after a minimum interval of 48 hours; the group average interval was 78 hours. All wrong responses were recorded upon answer sheets so constructed that values could be determined easily.

Subjects: There were 100 subjects used in this study. An effort was made to obtain a representative group of acuity values, as indicated by scores on the Grow chart. It is obvious that a service group is preselected and not truly representative of the population as a whole. This factor notwithstanding, Table 1 shows to what extent this group does correspond with that of previous studies (1,2) which indicate that 25% -35% of the population have less than 20/20 vision without glasses. The effort was made to obtain such a group, although this was not a normative study, because it was believed that the efficiency and reliability of the tests should be determined by including representative levels of subnormal acuity as well as 20/20 acuity and above. Using male subjects only, the population was taken from:

1. Volunteers from the officer and enlisted personnel attached to the Main Dispensary at Pensacola.
2. Students from a class of Hospital Corpsmen under training as Aviation Medicine Technicians.
3. Enlisted personnel appearing for refractions at the Eye Clinic prior to administration of homatropine.

The age range represented by this group was from 18.5 to 45 years with a me-

dian of 20½ years, mode of 19.0 years and mean age of 22 years 8 months.

Equipment and testing method: The equipment included a modified form of the Navy Grow chart, the Sight Screener and four trans-illuminated test targets* as discussed above and shown in Fig. 1-4.

During the original planning of procedure, certain criteria were established for terminating testing on any target. This procedure was discontinued, however, when it was found that subjects who would have been stopped at a certain level on this basis were able to continue and read subsequent lines successfully. (See discussion of tests). For this reason the testing on any target was allowed to continue until the subject was unable to proceed. He was encouraged to do the best he could, the examiner assuming the responsibility for encouraging those who had a tendency to "give up" easily and also for terminating tests. During monocular tests, the subjects were given a standard monocular eye screen of aluminum which bridged the nose and could be reversed to accommodate the eye being tested. (Fig. 2) No subjects were tested while wearing a refractive correction.

The levels of acuity tested by this battery of targets are presented in Table 2. It will be noted that the New London test varies somewhat from the values in the left hand column. The levels indicated as tested by the Navy Grow chart are those established by the "walk-up" positions chosen to correspond with levels of the other targets. The right hand column is a logarithmic translation of acuity values computed to facilitate statistical analysis. log score = 100 x $\log_{10}$(10 x VA) where VA means Visual Angle.

A. GROW CHART (Fig. 3) The standard Navy Grow chart consists of seven

* Produced by Bausch & Lomb Optical Company

lines of 11 characters to be read at 20' distance for a 20/20 Snellen rating. Two lines with 11 characters are available for testing 20/15 vision at 20' and one line of 11 characters for testing 20/10 vision at 20', the acuity values of these three lines being established by a decrement in size of the test characters. Two charts were prepared with alternate lines covered by a grill of white cardboard of the same reflective value as the background of the test card. This modification is in keeping with recommendations for presenting charts of this nature.

The test was given in accordance with Navy procedure, vision first being tested at 20' with subsequent walking forward to predetermined positions until a line could be read with two errors or less. To minimize the memory factor, more than one line was used or lines were read backward. For low levels of acuity the "walk-up" system presented positions equivalent to Snellen 20/22, 20/24, 20/26, 20/28, 20/30, 20/32, 20/34, 20/36, 20/38, 20/40, 20/50 and 20/100.

The illumination falling upon the target was 34.0 apparent foot candles, coming from a 200 watt bulb located 1 meter in front of and 1 meter above the center line of the target. This illumination and the above Snellen equivalents were used to equate the illumination and levels of acuity discrimination with those of the other targets employed in the study. Scoring of the Grow target followed the Navy practice of crediting the line of highest acuity read with two errors or less.

B. SIGHT SCREENER: This standard apparatus (Fig. 1) employs polarization contrast as an occluding method. It measures both monocular and binocular visual efficiency while both eyes remain open. Only the distance acuity section of this test was used, the values tested being shown in Table 2.

The subject is seated before the instrument with his head steadied by a head rest. The test line, located on a slide, is positioned by means of a knob which is operated by the examiner.

Scoring of the Sight Screener test was confined to one system, that of crediting the highest value at which one or no error was made in four responses. The values represented by fewer than four characters (1 each for 20/200 and 20/100; 2 for 20/70) were credited only when no error was made.

C. TRANS-ILLUMINATED TARGETS: The four trans-illuminated type targets include the New London test (Fig. 3), a Randolph Field test which employs a decrement of one unit per character (Fig. 4), a Randolph Field test with a 3-unit decrement for groups of three characters (Fig.4), and the checkerboard test of acuity (Fig. 3).

In a trans-illuminated type of target, diffuse light passes through glass plates upon which the test objects or characters are mounted. In contrast, the Snellen and Grow type are illuminated by reflection. Trans-illumination has been employed previously in various apparatus such as the Ortho-Rater, Sight Screener, and early attempts at letter chart illumination. The test targets used in this study were made on photographic film and placed between two plates which were then sealed as a unit.

The plates were presented in cabinets which were developed for this purpose. These cabinets (Fig. 3) are approximately 36" x 27" x 8". They are divided into halves with semicylindrical backgrounds for near-uniform reflection throughout from the 30 watt white fluorescent bulb which is placed in the front center of the cabinet. The resultant uniformity of illumination is shown in Fig. 3, where one half of a cabinet is open. Each half of the cabinet is further divided into two openings of $10\frac{1}{2}$" x $13\frac{1}{2}$". Guides permit in-

sertion of targets such as the above in a centered position. One cabinet was modified (Fig. 4) for this study in order to present but one target while maintaining constant surround, by the addition of four gate panels which could occlude any combination of targets.

Of the four trans-illuminated tests presented in these cabinets, two consisted of two plates while the other two were confined to a single plate each. Thus, there were two openings in one cabinet which were occluded during this study. The positions in which the targets were placed (Fig. 1) were established after a study of the apparent foot candle illuminations of the four openings of each cabinet as well as the transmission properties of the individual target plates. The afc values of the plates in the position used are presented below, each figure representing an average of 20 readings:

Plate	afc
Top Checkerboard	39.0
Lower Checkerboard	40.0
Randolph 3-Unit	40.0
Randolph 1-Unit	37.5
Top New London	41.0
Lower New London	40.0

These targets were read from the 20' distance, with 16', 10' and, in a few cases, 8' positions used for testing low acuities. The last position mentioned was used primarily to eliminate the memory factor. Less than 20% of the subjects required "walk-up" on more than one target. The "walk-up" positions were used only when necessary, the subject returning to the 20' position for subsequent tests.

1. NEW LONDON TEST: (Fig. 3)

The values of acuity for the lines of this test are shown in Table 2. The subject, standing at the 20' position, occluded his left eye with

the shield. The test targets (two plates) were exposed and he was asked to read the letters.

All lines with 8 characters and the 20/33.3 line of 7 characters were credited when 2 errors or less were made. The last line meeting this requirement was credited although previous lines might have been read with more than 2 errors. Other lines were credited with 1 error or no error, with the exception of the 20/200 line of KC which never was credited because it was memorized so readily.

2. RANDOLPH FIELD 1-Unit:

This target, shown in Fig. 4, has single characters representing unit decrement levels from 20/40 to 20/5. The subject was tested in the usual manner at 20' and was moved forward to "walk-up" positions only under circumstances previously discussed.

Two scoring systems were employed for this test:

1. The acuity value of the last character correctly identified. This established the maximum acuity.

2. The acuity value of the character preceding the first failure on two characters in succession. The relative merits of the two systems, in terms of reliability and validity, are shown below.

3. RANDOLPH FIELD 3-Unit:

This target (Fig. 4) presents groups of three characters, two groups in a row, with three units of decrement between groups. The acuity values range from 20/40 Snellen equivalent to 20/70. The subject was tested at 20' and moved forward when necessary.

Two scoring systems were employed for this target:

1. Credit was given for the last group in which two of three char-

acters were correctly identified.

2. Credit was given for the last group prior to the first group in which two errors occurred.

4. CHECKERBOARD: This target, consisting of two plates, is shown in Fig. 3. The procedure established for its presentation was as follows: "In the first group of diamonds (squares), upper left, do you see one in which there is a checkerboard pattern?" "Where is it in the second group?" "The third group?" When S. is acquainted with the response desired - "All right, now tell me where it is in each group. It never will be in the center - always at the top, right, bottom or left. When you are not certain as to its location, guess."

Credit was given for the last group in which 1 error or no error was made. Other scoring systems were considered for this test though not employed for reasons mentioned in a later discussion.

STATISTICAL ANALYSIS

Test-retest reliability coefficients of each test target for the right eye, left eye, and both eyes, respectively, were derived by the product-moment method of correlation. Differences between test and retest means were also computed and the statistical significance of the differences was determined by the *t* test.

For the right eye, left eye, and both eyes, respectively, test scores on the various targets were intercorrelated. Differences between means on the various targets were computed, and the statistical significance of the differences was determined by the *t* test.

The statistical reliability of all coefficients of correlation was determined by deriving the ratio between each coefficient and its standard error. The mean scores, standard deviation of the distribution, and standard

error of the mean were obtained for each array of scores.

In order to avoid difficulties inherent in the correlation and averaging of ratios, the scores used in all computations were the logarithmic translations of the Snellen-equivalent scores obtained in the testing procedure.

DISCUSSION

General:

With the exception of the checkerboard plates and the Sight Screener, there is little practical difference in the overall test-retest reliabilities of the various targets. The two targets excepted have somewhat lower overall test-retest reliabilities than the remainder. The lowest coefficient for the checkerboard plates, .76, occurs in the tests of the left eye, and the lowest coefficient for the Sight Screener, .71, occurs in the tests for both eyes. (Table 3)

These two targets also have the lowest coefficients of correlation with the Grow chart, in both monocular and binocular acuity. There is no practical difference in the correlation of the remaining targets with the Grow test. (Table 4).

All retests, monocular and binocular, with all targets result in higher mean scores than were obtained on the tests, and all but three test-retest differences are statistically reliable. (Table 3) The order of these differences, however, is so small that little practical significance would seem to attach to most of them. The highest difference, which occurs between the test and retest means of the checkerboard target for the right eye, amounts to 5.83 log units, or 2.75 feet in the denominators of the Snellen ratios. In other words, not only are test-retest scores on the var-

ious targets highly correlated, but there is little practical gain in acuity scores on the retest. The fact that the largest overall retest gains are shown in the case of the checkerboard plates may be explained by the increasing familiarity of the subjects with the target, and the consequent discovery by some of the shift in the selection of cues. Whenever this discovery occurred during the retest, a subject was able not only to add another line to his credit, but frequently also to read all the remaining lines of the plate.

In considering the various targets for actual day-by-day testing, it is important to know not only the extent to which they intercorrelate, but also the extent to which the acuity scores derived from each are commensurate with the acuity scores derived from the others. Table 5, which presents differences between test means, provides for such comparisons. Table 5 indicates that there is considerable consistency in the ranks of the mean scores; i.e., some targets, as scored in this study, consistently tend to give higher appraisals of visual acuity than others. In general, the highest appraisals of acuity are given by both scorings of the Randolph Field 1-unit target and the "easier" first scorings of the Randolph Field 3-unit target. The lowest appraisals of acuity are given by the checkerboard type plates and the New London target,and median appraisals are given by the Grow test, the Sight Screener, and the "harder" second scoring of the Randolph Field 3-unit target. Most of the differences in mean scores are highly reliable statistically. It is doubtful, however, that they have immediate practical importance. The largest difference shown in the table, a difference of 14.40 in mean log score between the checkerboard plates and the Randolph Field 1-unit plate (first scoring, right eye), amounts to approximately 5.5 feet in the

denominators of the Snellen ratios. Taking the Grow test as a median, and comparing its mean scores with the mean scores of the highest ranking test, (Randolph Field 1-unit plate, first scoring), the differences reduce to approximately 2.5 feet, 3.9 feet, and 2.7 feet, for right eye, left eye, and both eyes, respectively. It will be further noted that it is possible to devise different scoring methods which could probably make the order of scores of each of the targets approach each other more closely, as was done with the two Randolph Field tests in this study. The second scoring of the Randolph Field 3-unit target, for example, resulted in mean scores which are not significantly different from the mean scores of the Grow test.

Specific:

Inasmuch as most of the targets were undergoing an extensive field testing for the first time, the design of this project included evaluation of their ease of administration and objective nature. To facilitate presentation, tests will be discussed individually.

A. GROW: It is evident that two factors have been varied in the presentation of the Grow chart:

1. A higher illumination (34.0 afc) than prescribed in standard Navy procedure was employed, in order to equate the illumination with that of the trans-illuminated targets. This change was adopted merely to obtain constant experimental conditions.

2. Alternate lines were deleted by means of a grid, resulting in a wider distance between the test lines. This change was adopted for experimental convenience, to eliminate confusion as to line requested and any undue influence of a concentration factor. In the opinion of the examiners, the addition of this grid adds appreciably to the ease of administration of

of the Grow chart.

B. SIGHT SCREENER: This piece of apparatus presented two difficulties, both of which might be eliminated with a minimum of modification. The occlusion by polarization is not complete, allowing a "ghost" image which reinforces that received by the eye being tested in monocular tests. Secondly, there should be some extension on the eye-piece which will hold the subject farther from the lenses. A regular stereoscope eye-piece with vents for circulation over the face of the lenses would serve to overcome fogging from body heat and contact by long eyelashes.

C. CHECKERBOARD: In its present form, this target is apparently neither so reliable nor valid as it might be with modification. During the testing program, it was observed that some subjects may read past the levels at which they actually perceive a checkerboard by making a brightness discrimination. It became evident that this shift in cues or the basis of judgment was taking place when it was noted that some subjects made frequent errors at levels 24/20, 20/20, or 20/17, but read the remainder of the plate perfectly.

Interrogation of these subjects confirmed the existence of this shift in criterion. The change in cues, and the accuracy of the brightness discrimination, seem further to be aided by a configuration formed by the squares composing each figure. Two squares which are not the checkerboard square, and the middle square form a "line". This "line" appears to be darker than the remainder of the pattern. The subject's choice is then immediately restricted to one of the remaining two squares, and his chances of selecting the correct one are at least 50/50. The subject then seems to pass through a stage in which he decides whether the checkerboard pattern should appear lighter or darker than the opposite square. If he decides that the overall

effect would be a lighter area, he is correct and, though having made errors at this critical level while passing through this process, he will continue throughout the remainder of the test with a perfect or near-perfect score. On the other hand, the subject may decide that the checkerboard would give a darker area. In this case, he would be in error throughout the remainder of the test. That the above situation does obtain became evident when it was noted that the wrong responses of the subjects were frequently the exact opposite of the correct responses.

It would seem that these limitations are not basic defects of the Ortho-Rater checkerboard technique, but are peculiar to the test plates as adapted for trans-illumination. Equating the brightness of the checkerboard and other squares, possibly by superposing the checkerboard on a neutral gray background, should reduce the difficulty.

D. NEW LONDON: Two items relative to the New London test are worth mentioning. The first is the departure in form of the "N" and the "G" (Fig. 3), which contributed an unnecessary amount of confusion to the testing situation. The second item is the number of characters used at the higher levels. This target was developed for testing low acuities as well as high while the subject remained at 20' distance from the cabinet. However, there are so few characters for testing the low acuities that the memory factor cannot be disregarded. Thus, where one or two characters are all that are used to test a certain level of acuity, there is considerable doubt as to the accuracy at these levels, especially after they have been exposed to one eye.

E. RANDOLPH FIELD 1-Unit: One questionable feature of this test is the mnemonic arrangement of some characters which becomes doubly important

when each character represents one unit or level of acuity. The main case in point, CVE*, would not be the aid to the Army personnel on which this test was validated as it was to the Navy personnel used in this study. The reliability and validity shown by this test indicate that finer quantitative testing of visual acuity is possible where job analysis warrants it.

F. RANDOLPH FIELD 3-Unit: This target is constructed with only six test letters, arranged in groups of three. The limited number of letters is recognized by some subjects, so they know that the last three letters on a line must be some combination of the three not seen in the first group. Also, some question might be raised as to the relative facility for memorizing groups of three characters as opposed to groups of other size, discounting mnemonic aids.

* CVE the Navy designation for auxillary aircraft carriers

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2. Project staff, OSRD Contract OEMsr-815. Memorandum No. 12(to Applied Psychology Panel, NDRC): Inter-relationships among seven tests of stereoscopic acuity and the relationship between two tests of visual acuity and two tests of phorias. Washington, D. C.: March 24, 1944.

TABLE 1

ACUITIES OF THE TEST POPULATION
as measured by Grow and
New London targets
N = 100

Snellen Equiv.	Right Eye		Left Eye		Both Eyes	
	Grow	New London	Grow	New London	Grow	New London
20/10	14		10	1	28	8
11		9		8		11
13		14		11		23
14		21		20		24
15	43		45		47	
17		10		14		12
20	20	18	25	20	14	6
22	3		3		4	
24	4		3		1	
25		11		10		8
26	1	1	2		1	
28	2		3		1	
30			1			
32	2					
33		5		7		2
34	2		1	1		2
35						1
36	1				2	
40	2				1	
41		1				
44	1		1			
50	2	7	4	5		2
56			1			
61				2		
67	2	1			1	
83						1
100	1	1	1			
125		1		1		

TABLE 2

TARGET ACUITY VALUES

Snellen Equiv.	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Log Score*
20/200			x		x		00.0
100			x		x	x	30.1
70					x		45.6
50			x		x	x	60.2
40	x	x		x	x	x	69.9
39	x						71.0
38	x					x	72.1
37	x	x					73.3
36	x					x	74.5
35	x						75.7
34	x	x		x		x	76.9
33	x		x(33.3)				78.3
32	x					x	79.6
31	x	x					81.0
30	x				x	x	82.4
29	x						83.9
28	x	x		x		x	85.4
27	x						87.0
26	x					x	88.6
25	x	x	x				90.3
24	x			x		x	92.1
23	x						93.9
22	x	x				x	95.9
21	x						97.9
20	x		x	x	x	x	100.0
19	x	x					102.1
18	x						104.5
17	x		x(16.6)x				107.2
16	x	x					109.7
15	x				x	x	112.4
14	x		x(14.3)x				115.5
13	x	x	x(12.5)				118.8
12	x			x			122.3
11	x		x(11.1)				126.0
10	x**	x	x	x	x	x	130.1

Test 1 Randolph Field unit decrement
Test 2 Randolph Field 3-unit "
Test 3 New London
Test 4 Checkerboard plates
Test 5 Sight Screener
Test 6 Grow-Navy Standard

* Log score = $100 \log_{10}(10 \times 1/VA)$

** This test extends to 20/5

TABLE 3

TEST - RETEST MEASURES

		TEST		RETEST		M. Diff. (Retest M minus Test M)	r***
		M	S.D.	M	S.D.		
GROW	rt	103.96	19.14	105.14	18.34	1.18	.91
	l	103.87	17.46	105.90	17.14	2.03**	.90
	b	112.24	14.87	115.19	14.49	2.95**	.89
SIGHT SCREENER	rt	103.94	16.53	106.92	14.81	2.98**	.84
	l	105.50	17.08	106.80	15.69	1.30	.84
	b	110.68	13.27	113.08	12.45	2.40**	.71
CHECKER-BOARD	rt	98.53	19.86	104.36	20.68	5.83**	.86
	l	100.13	18.26	105.03	19.65	4.90**	.76
	b	108.57	18.47	111.75	17.75	3.18**	.81
NEW LONDON	rt	101.64	21.53	104.71	20.88	3.07**	.92
	l	102.10	19.94	103.36	20.66	1.26*	.93
	b	111.48	16.53	113.68	15.18	2.20**	.92
RF 1-Unit (1)	rt	112.93	19.58	115.62	18.72	2.69**	.94
	l	114.48	16.81	115.56	18.23	1.08	.92
	b	121.42	13.56	123.18	12.75	1.76**	.90
RF 1-Unit (2)	rt	109.29	22.39	111.95	20.10	2.66**	.89
	l	110.81	18.72	112.70	20.73	1.89*	.87
	b	119.23	15.05	122.02	13.74	2.79**	.85
RF 3-Unit (1)	rt	105.94	21.73	108.88	20.17	2.94**	.93
	l	106.29	19.35	108.70	19.77	2.41**	.88
	b	114.76	14.71	116.60	14.56	1.84**	.85
RF 3-Unit (2)	rt	102.85	22.82	106.07	22.80	3.22**	.89
	l	102.44	22.53	106.74	21.29	4.30**	.86
	b	112.01	18.58	115.19	15.32	3.18**	.83

(1) First scoring system
(2) Second scoring system
* Statistically reliable at a p level greater than .01, but less than .05.
** Statistically reliable at a p level of .01 or less.
*** All r's are statistically reliable at a p level of .01 or less.

TABLE 4

INTERCORRELATIONS AMONG TEST SCORES

	Grow	S.S.	Check'bd	N.L.	R.F.1	R.F.3	R.F.1(2)	R.F.3(2)
Grow	.91	.76	.72	.88	.89	.89	.89	.86
Sight Screener		.84	.67	.82	.77	.76	.75	.78
Checkerboard			.86	.74	.76	.73	.76	.74
New London				.92	.91	.88	.90	.90
Randolph Field 1-Unit					.94	.92	.95	.90
Randolph Field 3-Unit						.93	.91	.95
RIGHT EYE								
Randolph Field 1-Unit (2)							.89	.90
Randolph Field 3-Unit (2)								.89
Grow	.90	.77	.67	.89	.90	.87	.87	.88
Sight Screener		.84	.48	.74	.75	.77	.73	.75
Checkerboard			.76	.67	.68	.68	.67	.70
New London				.93	.90	.90	.89	.88
Randolph Field 1-Unit					.92	.91	.92	.87
Randolph Field 3-Unit						.88	.87	.95
LEFT EYE								
Randolph Field 1-Unit (2)							.87	.86
Randolph Field 3-Unit (2)								.86
Grow	.89	.76	.69	.86	.85	.82	.84	.83
Sight Screener		.71	.51	.68	.72	.69	.70	.73
Checkerboard			.81	.72	.72	.70	.72	.66
New London				.92	.87	.84	.87	.83
Randolph Field 1-Unit					.91	.84	.92	.82
Randolph Field 3-Unit						.85	.85	.93
BOTH EYES								
Randolph Field 1-Unit (2)							.85	.83
Randolph Field 3-Unit (2)								.83

All r's are statistically reliable at a probability level of less than .01.

TABLE 5

	Grow	S.S.	Checkb'd	N.L.	RF 1	RF 3	RF 1(2)	RF 3(2)
Mean	103.96	103.94	98.53	101.64	112.93	105.94	102.29	102.85
Grow Minus	0	0.02	5.43**	2.32*	-8.97**	-1.98*	-5.33**	1.11
Sight " Screener		0	5.41**	2.30*	-8.99**	-2.00	-5.35**	1.09
Checker " Board			0	-3.11*	-14.40**	-7.41**	-10.76**	-4.32**
New " London				0	-11.29**	-4.30**	-7.65**	-1.21
RF " 1-Unit			RIGHT EYE		0	6.99**	3.64**	10.08**
RF " 3-Unit						0	-3.35**	3.09**
RF " 1-Unit(2)							0	6.44**
Mean	103.87	105.50	100.13	102.10	114.48	106.29	110.81	102.44
Grow Minus	0	-1.63	3.74**	1.77*	-10.61**	-2.42**	-6.94**	1.43
Sight " Screener		0	-5.37**	3.40**	-8.98**	-0.79	-5.31**	3.06*
Checker " Board			0	-1.97	-14.35**	-6.16**	-10.68**	-2.31
New " London				0	-12.38**	-4.19**	-8.71**	-0.34
RF " 1-Unit			LEFT EYE		0	8.19**	3.67**	12.04**
RF " 3-Unit						0	-4.52**	3.85**
RF " 1-Unit							0	8.37**
Mean	112.24	110.68	108.57	111.48	121.42	114.76	119.23	112.01
Grow Minus	0	1.56	3.67**	0.76	-9.18**	-2.52**	-6.99**	0.23
Sight " Screener		0	2.11	-0.80	-10.74**	-4.08**	-8.55**	-1.33
Checker " Board			0	-2.91*	-12.85**	-6.19**	-10.66**	-3.44*
New " London				0	-9.94**	-3.28**	-7.75**	-0.53
RF " 1-Unit			BOTH EYES		0	6.66**	2.19**	9.41**
RF " 3-Unit						0	-4.47**	2.75**
RF " 1-Unit							0	7.22**

* Statistically reliable at a p level greater than .01 but less than .05.
** Statistically reliable at a p level of .01 or less.

Fig. 1

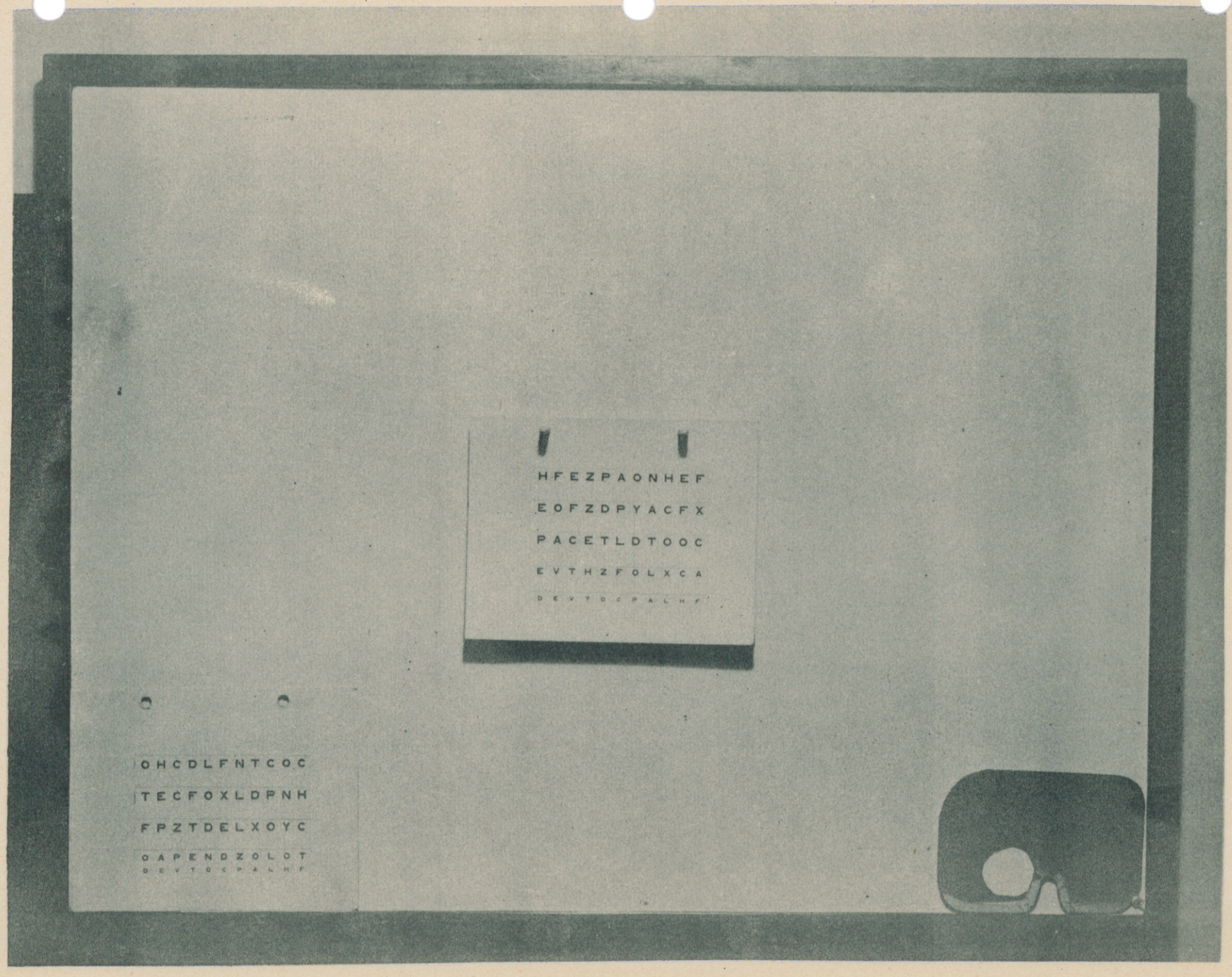
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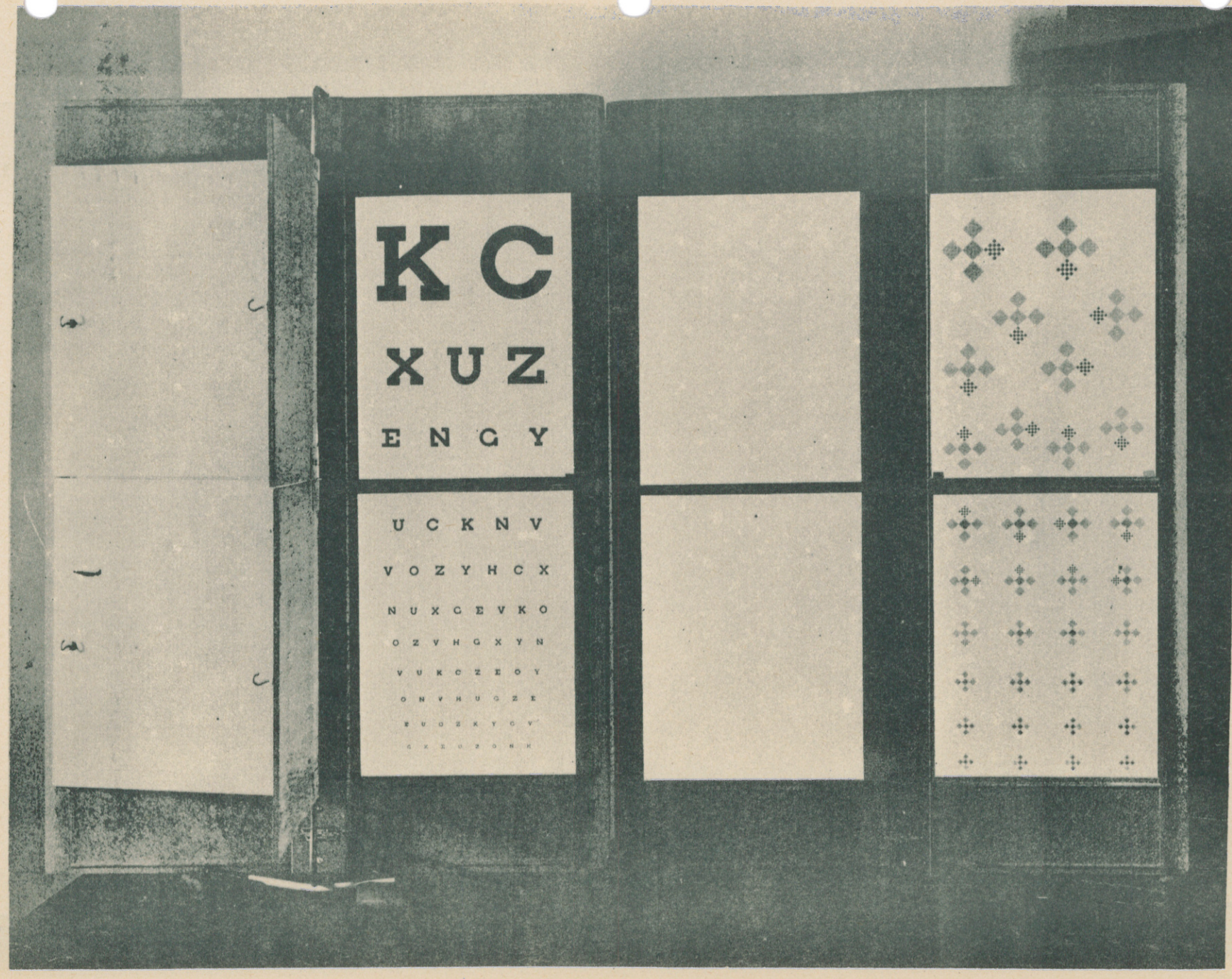
Fig. 2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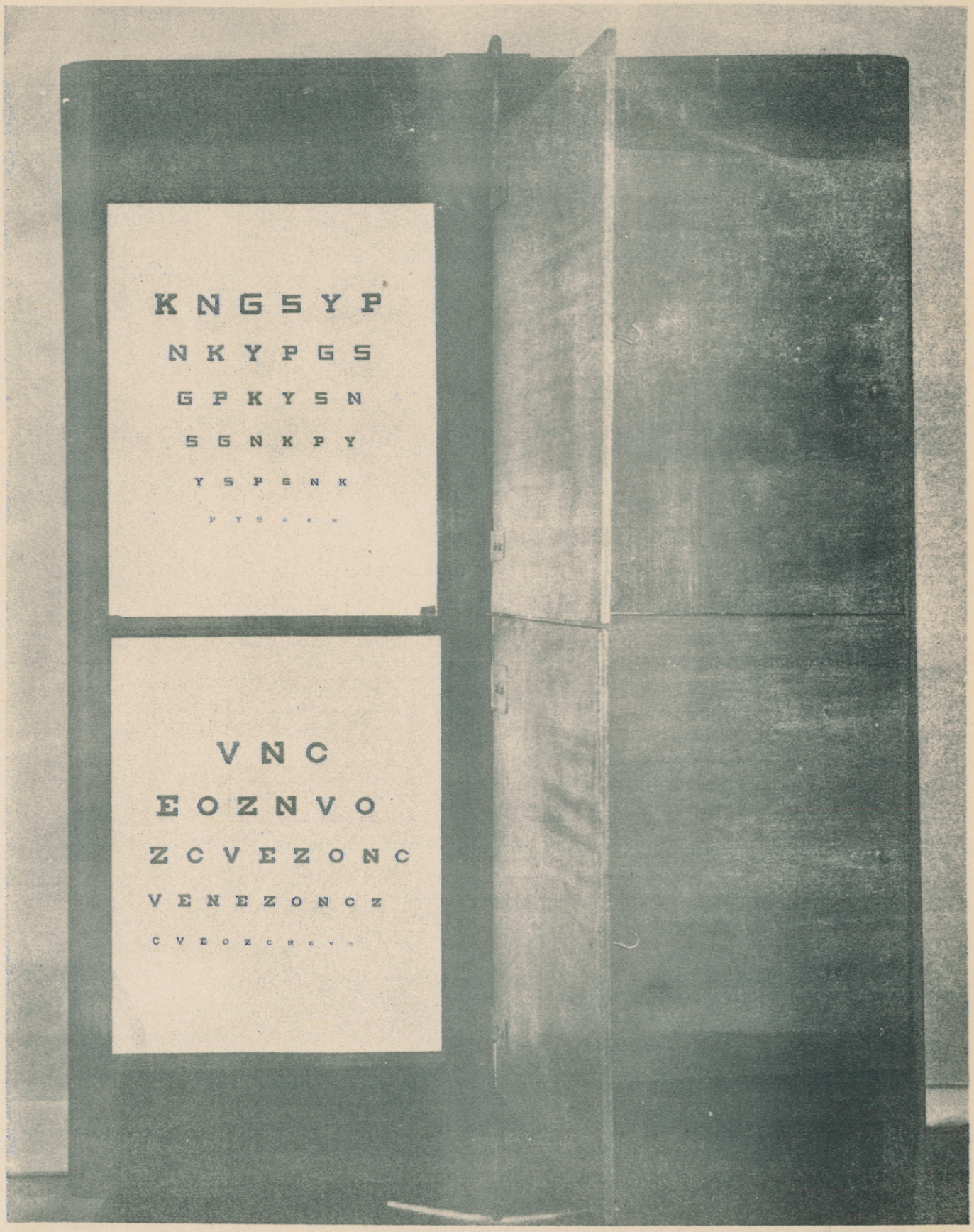
E U O Z K Y C V
C X E U Z O N H

Fig. 3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V N C
Z C V E Z O N C
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Fig. 4